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THE INFLUENCE OF VISUAL GUIDANCE IN MAZE LEARNING

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For this experiment, a new type of stylus maze was constructed of such a character that the correct path and the cul de sacs can not be distinguished from each other by means of vision. The grooves for the stylus were milled as represented by the cross section diagram of Fig. 1. The stylus

Fig. 1. Cross section of maze representing two grooves.

consisted of a hard rubber handle at one end of which was attached by a ball and socket joint a circular metal disc of such dimensions that it moved very easily through the lower part of the groove. The pattern of the maze is represented by the diagram of Fig. 2. Its dimensions are 16 x 16½ in. The starting point is located at *A*, while position *B* is the goal or objective of each trial. The stylus is inserted in the groove at *A*, and the entrance is then blocked by a sliding metal strip. The stylus can not now be removed from the maze until position *B* is reached, where it may be easily lifted from the groove and again be inserted at *A* for the succeeding trial. So far as vision is concerned, all possible paths from *A* lead to the goal at *B*, while as a matter of fact all paths, with one exception, are blocked by invisible stops whose

positions are represented by the short lines drawn across the grooves. With the aid of these lines, the course of the true path and the positions of the blind alleys are readily apparent

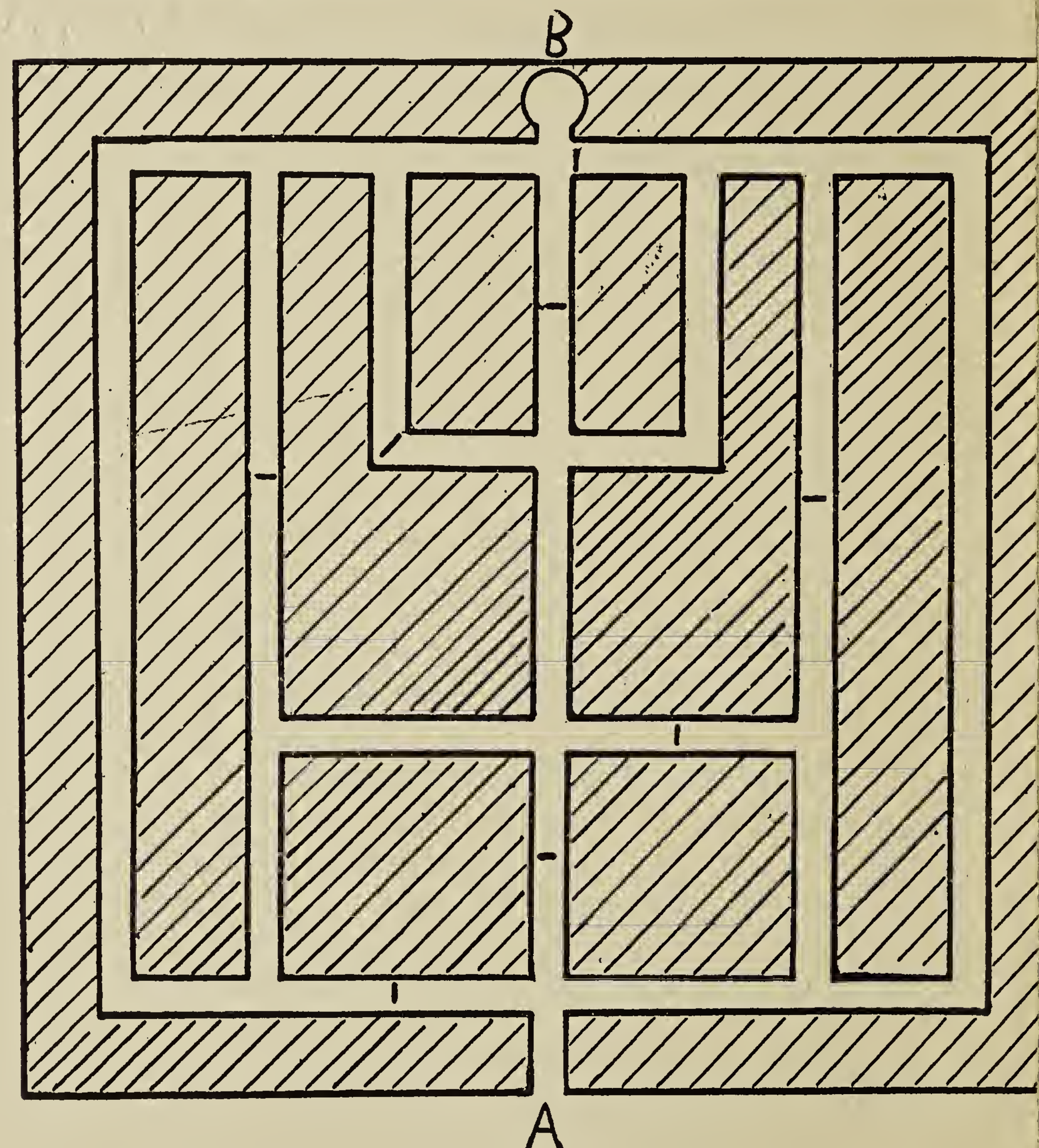

FIG. 2. Diagram of maze pattern. Lines drawn across the grooves represent the positions of the invisible stops.

to the reader. These stops project out in the lower part of the groove a sufficient distance to prevent the passage of the stylus disc, but not far enough to be visible to the subject.

The essential feature of this type of maze is the fact that the stops are invisible. As a consequence, the subject is unable to distinguish between the true path and the cul de sacs by means of vision. The maze may thus be learned in whole or part with the coöperation of visual perception, or it may be mastered in the usual manner by excluding vision by means of an intervening screen.

1. *Varying Amounts of Initial Visual Guidance.*—Six groups of subjects were employed in the first experiment. Group I. was permitted one minute for a visual inspection of the maze with instructions to obtain all the aid possible for its subsequent mastery. At the end of the period, the screen was placed in position and the maze was mastered with vision excluded. Group II. was permitted the use of vision during the first trial, and the mastery of the maze was then completed without vision. Groups III., IV., and V. were likewise allowed the use of their eyes during the initial 2, 3, and 5 trials respectively, and the learning was then completed without the aid of vision. These records are to be compared with those of Group VI. that learned the maze entirely without the coöperation of sight. This group will be termed the normal. In all cases, the maze was learned by a series of successive trials.

The comparative data are given in Table I. The first column lists the groups and the conditions of learning. In the second column is given the number of subjects employed in each group. Following are the average trial and error records for the various groups. These are total values and they include the records for both the guided and the unguided trials. The last two columns represent the influence of the visual control as measured in terms of the normal record. The positive values indicate the percentages of saving due to vision, while the negative values represent its detrimental influence. The group given five trials with vision completed the mastery of the maze with an additional 5.5 trials. As compared with the normal records, this amount of guidance was effective in producing a saving of 46.1 percent in trials and 80.9 percent in errors.

Table I

Influence of Initial Visual Guidance

Group	Number	Trials	Errors	Percentages of Saving	
				Tr.	Er.
I. Inspection	6	28.0	143.0	−43.6	28.8
II. 1 trial	12	20.4	86.7	− 4.6	56.9
III. 2 trials	12	19.0	95.0	2.5	52.8
IV. 3 trials	11	11.0	30.5	43.6	84.9
V. 5 trials	12	10.5	38.6	46.1	80.9
VI. Normal	11	19.5	201.2	——	——

The one-minute period of visual inspection of the maze exerted a detrimental effect upon the mastery of the problem when measured in terms of trials. It exerted a beneficial effect upon the error record, reducing the number of errors per subject by 28.8 percent in spite of the increase in the number of trials.

One and two trials with vision were approximately equal in effectiveness. They exerted no appreciable influence upon the total number of trials necessary to learn the maze, but these amounts of guidance were effective in decreasing the number of errors by over 50 percent.

Three and five trials with vision are apparently equal in effectiveness. They decreased the number of trials by at least 40 percent and the number of errors by 80 percent.

Three and five trials with vision are much more effective than either one or two trials. Obviously the effectiveness of visual guidance is not proportional to its amount. One and two trials with vision exert a much more favorable effect than does one minute of visual inspection. This amount of time devoted to visual inspection is approximately the same as that secured when vision is permitted during the first trial.

In all cases, the visual control is much more effective in preventing and eliminating errors than in reducing the number of trials.

Vision operates to prevent error not only during the trials in which its use is permitted, but also during the post-visual

period of learning. The relative effectiveness of the control during the visual and post-visual stages of learning may be determined from the data of Table II. The second column gives the total error decrease during the trials in which vision was permitted. These values indicate the effectiveness of vision in preventing error in absolute terms. The third column states the average decrease per trial during the visual period. The fourth column gives the total decrease relative to the corresponding normal record in percentage terms. Vision operated to prevent 90 percent of the normal amount of error during the first three trials. The same values for the post-visual period are given in columns 5, 6, and 7 respectively.

TABLE II

ERROR DECREASE DURING VISUAL AND POST-VISUAL PERIODS

Group	Visual Period			Post-visual Period		
	Total	Ave.	Percent	Total	Ave.	Percent
II. 1 trial.......	27.3	27.3	70	87.2	4.5	54
III. 2 trials......	74.0	37.0	80	32.2	1.9	30
IV. 3 trials......	104.4	34.8	90	66.3	8.3	77
V. 5 trials......	122.2	24.4	86	40.4	6.5	68

Visual perception is extremely effective in preventing and eliminating error. When vision is permitted for one to five trials, the normal error record is decreased by 70 to 90 percent. The total number of errors prevented is not proportional to the number of trials. This result is due to the fact that the normal error curve falls very rapidly during the early trials. Stated in relative or percentage terms, the effectiveness of vision increases up to the third trial. The decreased value for five trials is due to the fact that with visual guidance practically all errors have been eliminated by this time.

There is no definite relation between the amount of visual guidance and the total saving of errors in the post-visual period. This fact may be accounted for in several ways. The post-visual periods differ considerably in length. With

three and five trials of guidance, a fewer number of trials are required to learn the problem (Table I.). With these amounts of guidance, the post-visual period begins at a later stage in the mastery of the problem. When but one guided run is permitted, its post-visual effects are exerted at a time when normally many errors are being made. Measured in terms of total errors saved, any factor will be more effective in the initial stage of learning than during the final runs when the mastery of the maze is practically completed.

The influence of differences of length of the post-visual period may be eliminated by comparing the four amounts of guidance in terms of the average saving per trial. A comparison in terms of the percentage of saving will eliminate the influence of differences of position. It is apparent that the post-visual effectiveness of guidance is not proportional to its amount when measured in average or percentage values. As in the case of trials, however, three and five guided runs are considerably more effective than one or two.

Measured in relative terms, the immediate effect of guidance is invariably much greater than its subsequent effect upon the post-visual stage of learning.

Similar results were obtained from a study of the error curves whose graphs are not given. The curves for the guided groups start at a considerably lower level and fall at a somewhat faster rate than that of the standard group. With the removal of the guidance, the curves immediately rise and then descend in an orderly manner. The post-visual effect of two guided runs is confined to five trials. The curve remains below that of the normal from the third to the eighth trial, and from this point on the two are practically identical. The post-visual effect of one guided run is more prolonged. Its curve remains below the level of the normal up to the eighteenth trial. The post-visual curves for three and five guided runs are quite similar. They consistently maintain a lower level than those of the groups given one and two guided trials. In general, three and five guided runs exert the most effect upon the post-visual stage of learning, while the least effect was exhibited by the guidance given for two trials.

The immediate effect of the guidance upon the error score is easy to explain. Its effects are to be explained in part in terms of visual perception and in part in terms of a memory of these visual data. Vision permitted the subject to locate the goal and make more systematic explorations in the attempt to reach it. After traversing a certain distance in the maze, vision enabled the subject to foresee that certain paths could not lead to the goal and as a consequence certain cul de sacs were never entered. Vision enabled the subjects to identify the blind alleys more readily. Without vision, a person may enter and emerge from a short cul de sac without any knowledge of its character. Vision reduced very materially the amount of retracing over the true path, and the number of entrances into a given cul de sac during any trial. Some retracing did occur occasionally. Subjects sometimes retraced in order to explore certain paths which had been previously passed without being entered. Even with vision a subject may become lost during the first trial and retrace as a consequence. The memory factor is apparently quite effective in reducing the number of errors in the succeeding trials.

There are two ways in which vision may be effective in the post-visual period. We may assume the retention of some memory of the visual appearance of the maze pattern and its subsequent utilization as a guiding factor. The second conception assumes that the act is learned in tactual and kinæsthetic terms. Visual perception is directly effective in preventing error and thus aiding the development of a more perfect tactual motor coördination, and it is this more highly perfected act which is carried over into the post-visual period. Subjects, who have been permitted the use of vision, enter the post-visual period at a more advanced stage in the learning process than do those persons to whom vision was denied. On this assumption, the groups given guidance will be able to complete the mastery of the problem with less time and effort than the normal group.

Both conceptions are plausible. They are not mutually exclusive alternatives and both may be true. No facts were

obtained which prove or disprove the second assumption. Several lines of evidence support the validity of the first hypothesis.

Visual inspection of the maze enabled the subjects to localize the goal and obtain some notion of the size and character of its pattern. This preliminary visual experience did not, however, permit any differentiation between the true and false paths. The effects of this inspection were retained and it exerted some influence upon the process of learning. Its influence upon trials was detrimental, but the total error record was decreased by 28.8 percent and the average number of errors per trial by 50 percent. The facts prove rather conclusively that a memory knowledge of the visual features of the maze can be utilized as a guiding factor.

The fact that the effectiveness of the visual control is not proportional to its amount can not be explained wholly on the basis of the tactual motor hypothesis. According to this conception, visual inspection should exert no effect, five guided runs should be more effective than three, and two trials more effective than one. The fact can be explained in terms of a memory of the visual data. Both detrimental and beneficial effects will result from an inadequate and partially incorrect notion of the appearance of the maze pattern. The beneficial effects will increase as the guiding concept becomes more definite and precise, and the maximal amount of benefit will be obtained from that amount of guidance necessary to develop a correct conception of the maze pattern. As a matter of fact, the maze was visually mastered at the end of the third trial by the majority of the subjects. Of the first two groups, but one of the twenty-four subjects obtained a visual mastery of the maze within two trials. When three guided trials were given, seven subjects were able to identify the correct path by sight. With five guided runs, seven subjects mastered the problem in terms of vision by the end of the third trial, and three others by the end of the fifth trial. The average number of trials necessary to learn this maze in visual terms is probably somewhere between

three and four. Since a correct notion of the maze pattern is attained in about three trials, any additional visual experience will be without effect.

The effectiveness of the memory factor was indicated by the remarks of the subjects. Its efficacy apparently varied with the individual. Some asserted that they retained an adequate memory of the appearance of the maze pattern and that the few errors made were due to carelessness. This type of subject traversed the maze slowly and carefully and made the best records. Some subjects exhibited a certain degree of uncertainty and indecision at the beginning of the first trial without vision. These people asserted that this uncertainty was due to the lack of any adequate memory of the visual path. Others did fairly well on the first trial but exhibited considerable hesitation at the beginning of the second trial. These subjects ascribed this hesitation to the fact that the appearance of the maze had been forgotten in the meantime. In other cases the subjects proceeded confidently until difficulties were encountered, and these mistakes were usually attributed to a wrong visual conception. A few subjects reported that this memory control was detrimental inasmuch as they discovered after several trials that they could do better by relying exclusively upon kinæsthetic clues for guidance.

After the maze was mastered without the use of vision, all groups were required to run it for several trials when vision was not excluded. All subjects in the groups given three and five trials of visual guidance made no errors in this test. Evidently these subjects had developed a correct notion of the appearance of the maze pathway, or their movements were guided wholly in kinæsthetic terms. In the two trial group, two subjects made one error each which they ascribed to an incorrect idea of the nature of the path. In the one trial group, one subject had developed a very erroneous concept of the maze as a visual object and as a consequence made twenty-two errors in his first attempt to traverse the maze with the use of vision. One error was made in the second

attempt, but the third was successful. Vision was now excluded and four errors resulted. Evidently the correction of the visual control had disturbed the kinæsthetic coördination. Three of the six subjects who had been given one minute for a preliminary inspection of the maze pattern made slight mistakes when attempting to traverse it with perceptual guidance. The test was also given to the group that learned the maze entirely without the aid of vision. These subjects invariably reported that the maze pattern looked very much different from what they had anticipated. Two individuals made slight mistakes which were apparently due to the fact that the introduction of vision increased speed. Two other subjects made errors because they were guided in part by vision.

Table III

Influence of Position of Guidance

Group	Guidance	Total Saved				Percentage Saved			
		Tr.	Err.	V.	P.V.	Tr.	Err.	V.	P.V.
III. 12........	1–2	.5	106.2	74.0	32.2	2.5	52.8	80	29
VII. 10........	5–6	3.3	53.4	16.7	36.7	17.0	21.0	75	67
VIII. 12........	9–10	– .5	17.2	.2	17.0	– 2.5	8.5	3	46

2. *Position of Visual Guidance.*—Two trials of visual guidance were introduced at different stages in the learning process. Group III. was permitted to utilize vision during the first two trials and was then required to master the maze without this aid. Group VII. ran the first four trials without vision. Visual guidance was then introduced during the fifth and sixth trials, and after this the mastery of the maze was completed with vision excluded. With group VIII., the visual guidance was introduced during the ninth and tenth trials. The comparative data are given in Table III. The results are stated in terms of the effects of the guidance relative to the records of group VI. that mastered the maze entirely without the aid of vision. Group VII. consisted of 10 subjects. Guidance was given during the fifth and sixth

trials. This group learned the problem in 3.3 fewer trials than did the normal, and made 53.4 fewer errors in so doing. Of these errors, 16.7 were saved during the period of guidance and 36.7 during the post-visual period of mastery. The values in the last four columns represent the same data stated in terms of percentages. For example, the saving of 16.7 errors which occurred during the two guided runs is 75 per-cent of the error record of the normal group for the corresponding trials.

Visual guidance introduced in the initial or final stages of learning exerts no appreciable effect upon the number of trials required to master the maze. Two guided runs in these positions are no more effective than an equal number of unguided trials. When two trials of visual guidance are inserted in the intermediate position, they exert a greater effect than a similar number of unguided trials.

Visual guidance for all positions is much more effective upon errors than trials. The earlier the introduction of vision, the greater is its effect upon the total error score.

Guidance in all cases is effective upon errors during both the visual and the post-visual stages of learning.

Considering the *immediate* effect of visual guidance upon errors, it is evident that the earlier its introduction, the greater is its effect when measured either in absolute or percentage terms. For the initial position, vision reduced the error score for all subjects. In the intermediate position, vision was effective only with those subjects who had made but little progress in error elimination. The introduction of vision in the final position was slightly effective with a few subjects, not effective with the majority of the individuals, and detrimental with two subjects. This distractive effect was apparently due to the fact that these individuals had developed an erroneous notion of the visual appearance of the true pathway, and consequently became confused and lost when vision was introduced.

The effect of vision during the post-visual period is greatest for the intermediate position when measured in terms of the

total errors saved, the average saving per trial, and the percentage of saving. The initial position is more effective than the final position in respect to the total and average number of errors saved. Measured in terms of the percentage of saving, guidance in the final position is the more effective. The saving resulting from visual guidance in the initial position is confined to the first five trials of the post-visual period. Guidance in the other positions manifests an effect throughout the post-visual period. The post-visual efficacy of guidance apparently varied with the individual. Guidance in the initial position was quite effective with some subjects and detrimental with others. When introduced in the intermediate position, guidance was effective in all cases. The efficacy of the control for the final position was confined to a few individuals.

No generalization can be made as to the most advantageous position in which to introduce a visual perceptual control. It is possible that more advantageous results might have been secured by the introduction of vision during the third and fourth trials. Moreover, the most effective position may vary with the amount of guidance given. The character of the problem may also be a conditioning factor.

3. *Influence of Indirect Visual Guidance.*—A final experiment tested the influence of indirect visual guidance by the use of map diagrams representing various features of the maze pattern. These diagrams were exact duplicates of the maze as to size. They were placed on the table at the left of the screened maze. The nature of these maps was explained to the subject and he was instructed to utilize the diagram in guiding his movements through the hidden maze.

Group IX. mastered the maze with the use of map *A*. This diagram represented all the possible pathways but it did not enable the subject to distinguish between the true path and the cul de sacs. It represented the maze pattern as it appeared to vision. Group X. learned the maze with the aid of map *B* which is represented in Fig. 2. This diagram was like that of map *A* with the single exception that

the positions of the various stops were indicated by lines drawn across the pathways. These lines enabled the subjects to distinguish between the cul de sacs and the true path. Group XI. utilized map *C* which represented the course of the true path. The subject was informed that the maze contained numerous cul de sacs but that these were not represented in the diagram. The comparative data of these groups are given in Table IV. in addition to the records of the normal group that mastered the maze without the aid of vision.

Table IV

Influence of Indirect Visual Guidance

Group	Number	Total Trials	Initial Errors	Total Errors	Percentage of Saving	
					Trials	Errors
VI. Normal......	12	19.8	54.1	201.2		
IX. Map *A*.......	11	11.8	47.5	105.4	40	48
X. Map *B*.......	11	7.5	3.7	14.7	62	93
XI. Map *C*.......	11	14.5	5.2	31.2	27	84

All three modes of indirect visual guidance were extremely effective in reducing both the number of trials and the amount of error requisite to the mastery of the problem. In all cases the controlling factor was more effective upon errors than trials.

The effectiveness of the guidance upon trials and errors was proportional to the amount of knowledge obtained from the diagram. Diagram *B* was the most effective, and obviously it gives the most information concerning the maze. Likewise, more information can be derived from diagram *C* than from map *A*.

There is no evidence that map *A* was effective in reducing the number of errors during the first trial. The difference between this value and that of the normal group may be accounted for in terms of chance. Moreover, this form of guidance was about equally effective upon both trials and errors. The error curve for this group begins approximately at the same height as that of the normal group, but it drops

very much more rapidly. This form of guidance exerts its main effect after the subject acquires some notion of the maze pattern during the initial trial.

Diagrams *B* and *C* were very effective during the first trial. The initial error records of these two groups were 3.7 and 5.2 respectively. The two curves maintain a similar relation to each other throughout the mastery of the problem. Both forms of guidance were very much more effective upon errors than trials.

The initial influence of these modes of indirect guidance may be compared with the direct effect of vision. The average error record for the initial trial of the four groups that were permitted the use of vision was 11.7. These conditions were like those obtaining for the group that utilized map *A*, with the single exception that the guidance was introduced directly in the one case and indirectly in the other. Direct guidance is the more effective not only during the initial run but throughout the learning process. The indirect guidance exerted by diagrams *B* and *C*, however, is more effective during the first trial than is the direct influence of visual perception.

With map *A*, the subjects were required at the end of each trial to identify the course of the true path in terms of the diagram. At no time were the subjects informed as to the correctness of these judgments. The learning process with this mode of guidance may thus be divided into two stages,—the initial period during which the pathway is being visually identified, and the final stage of completing the mastery of the problem. The records for the two periods of learning are given in Table V.

Table V

Two Stages of Learning with the Use of Map *A*

	Trials	Initial Error	Total Error	Average Error
Initial period	3.8	47.5	92.0	24.2
Final period	8.0	2.0	13.4	1.7

The first identification was incorrect with each subject. Three of the eleven subjects were successful after the second run. The average number of trials required by the group to master the maze in visual terms was 3.8, and the average error record per trial for this period was 24.2.

A visual mastery of the maze did not enable the subjects to traverse it without error. Eight additional trials were required. Individuals differ in their ability to guide their movements by a visual diagram. Two subjects were able to run the maze correctly as soon as they succeeded in identifying the pathway on the map. A third subject made 2 errors in his first attempt but was successful thereafter. A majority of the individuals required a considerable number of trials to complete the mastery of the problem. Few errors, however, were made in the final period. Of the 88 trials occurring during this period, an error score greater than 3 occurred in but three runs. The errors were slight but difficult to eliminate.

Similar results obtained with the use of map *B* which enabled the subjects to identify the course of the true path before attempting to run it. One subject was able to traverse it successfully on his first attempt, while another subject mastered the problem in one trial. Other individuals manifested considerable difficulty in guiding their movements by means of the diagram, but in all cases very few errors were made in any trial.

The subject's confidence in his identification was in general proportional to its correctness. The first confident judgment was invariably correct, and with the exception of one subject a correct identification was never subsequently revised. This individual correctly and confidently identified the true path at the end of the third trial. This judgment persisted for the fourth and fifth runs, and a wrong path was then chosen at the end of the sixth trial. The subject reverted to his previous correct choice on the next trial. This judgment was again revised after the ninth run and this wrong conception persisted until the problem was completely learned. We have

here the anomalous case of the development of the proper kinæsthetic motor coördination under the supervision of a wrong visual conception. The record of this subject, however, was not unusual in other respects. His trial and error scores were somewhat above the average for the group. Poorer scores were made by other individuals, and the deviation from the group average may well be accounted for in terms of chance. His error of identification was slight, however. When required to run the maze with the aid of direct vision, this individual made but one error in his first attempt.

During the initial period, the subject acquires two factors which are potentially significant for the subsequent mastery of the problem. The correct identification of the true pathway on the diagram is one. The second factor is the kinæsthetic motor coördination which has been developed during these trials. The relative value of the two factors may be determined from a comparison of the records for the final period with those obtained by the group that used map *B* as a guide. Group IX. learned to identify the true path on map *A* after 3.8 trials. Group X. was furnished this means of identification by map *B*. Group X. thus began the problem at a point comparable with that attained by group IX. upon entering upon the final period of mastery. Any difference in the two records must be due to the influence of the kinæsthetic-motor tendencies which were developed during the initial period. The comparative data are given in Table VI.

TABLE VI

INFLUENCE OF VISUAL IDENTIFICATION OF THE TRUE PATH

	Trials	Initial Error	Total Error	Average Error
Map *A*, final period.......	8.0	2.0	13.0	1.7
Map *B*..................	7.5	3.7	14.7	1.9

The two sets of records are practically identical in every respect. We are thus forced to conclude that the motor activity involved in running the maze during the initial period

was primarily valuable on account of its visual consequences. Presumably certain kinæsthetic motor tendencies were also acquired, but apparently these tendencies must have exerted both detrimental and beneficial effects upon the subsequent process of learning.

After the problem was learned, certain subjects were required to run the maze without the use of the diagram. Five individuals of group IX. were subjected to the test. Two ran the maze perfectly for several successive trials, one made a slight error in his first attempt, while two experienced some difficulty for several trials. Ten subjects of group X. were tested. Six ran the maze perfectly. Three made a few errors for several trials, while one individual experienced considerable difficulty in mastering this new phase of the problem. He required 12 trials and made 17 errors in learning to adjust to the new situation, as compared with 13 trials and 30 errors in learning to run the maze with the aid of the diagram. Evidently individuals differ very materially in their reliance upon the perceptual control after the problem is learned. The ability to run the maze without the aid of the diagram was apparently not correlated with the number of trials required to learn the problem. In this connection it was noticed that several subjects dispensed with the perceptual use of the diagram when the problem was about half mastered. In response to inquiries they replied that they preferred to rely upon a memory of the diagram as a control. Others reported that it made no difference whether they perceived or remembered the diagram in the later stages of learning. On the other hand, some individuals felt that the perceptual means of control was essential to a good record.

When the diagram was removed after the problem was mastered, the maze was traversed in terms of kinæsthesis or by means of a memory of the diagram. We have no decisive data upon which to base an estimate as to the relative importance of the two factors. Individuals differed in their subjective estimates of the importance of the memory factor, but such reports can not be taken seriously.

4. *Influence of a Visual Control derived from Kinæsthetic Data.*—Although any visual perceptual contact with the maze was denied the normal group, it must not be supposed that all modes of visual guidance were excluded. Under these conditions, subjects do gradually construct from their unseen movements some sort of an idea of the visual appearance of the true path. It is reasonable to suppose that this conceptual schema as it develops operates in turn to influence the succeeding attempts at traversing the maze, for our previous experiments have indicated the effectiveness of such concepts when derived from visual perceptual data.

The question as to the influence of such a control can be answered by a comparative study of the records of blind and normal subjects. I am indebted to Miss Helen Koch for the data given in Table VII. which were obtained with the use of a different maze from that employed in our experiments. The normal group consisted of ten college students. The table gives their average scores in trials, total errors and total time, in addition to the poorest record obtained for each of these three measures. The three subjects with defective vision were also college students. Subject *A* was able to see shadow differences in the visual world. Subjects *B* and *C* have been totally blind from birth. Subject *B* was a Phi Beta Kappa student, and subject *C* was able to enter the Law School after graduation from college. The records were obtained during their undergraduate work.

TABLE VII

COMPARISON OF NORMAL AND BLIND SUBJECTS

	Trials	Total Errors	Total Seconds
Normal average	44.3 ± 21.8	325 ± 197	1,466 ± 766
Poorest normal score	97	740	4,112
Subject *A*	46	566	1,731
Subject *B*	92	2,705	9,595
Subject *C*	83	3,671	7,291

There is no conclusive evidence that the ability of subject *A* was limited by his visual defect. His record in every case

was less than the poorest normal score. While his values were greater than the corresponding normal averages, yet in only one case do they exceed the average range of normal variability.

The totally blind subjects were evidently at some disadvantage in mastering such an act of skill. Their scores for trials exceed the average range of normal variability, but lie within the maximal range. Both the error and time values, however, lie far beyond the maximal range of normal variability. The error records are four to five times larger than the poorest normal score, while the time values are about twice that of the largest normal record. The visual deficiency of these subjects has certainly affected their time and error records, and possibly it has influenced their trial scores to a slight extent.

More comparative data are necessary for any confident generalizations. Moreover, it is somewhat of an assumption to maintain that the totally blind subjects were at a disadvantage primarily for the lack of a capacity for visualization. Granted the assumption, however, it is to be noted that the results confirm our former conclusions that the indirect mode of visual control is much more effective in reducing errors than trials.

Our experiments have been concerned with a general problem of considerable theoretical and practical importance, viz., the significance of the visual processes in the acquisition and performance of various acts of skill. As a general rule, both the direct and indirect participation of vision in these activities has been largely ignored. It has been the usual custom to describe such activities wholly in tactual and kinæsthetic terms. Our results at least indicate the probability that the visual modes of control are much more effective in the acquisition and performance of acts of skill than hitherto suspected.

SMALLER VS. LARGER UNITS IN LEARNING THE MAZE

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Investigation has raised a doubt in the minds of some[1] concerning the validity of the statement that to 'learn by wholes rather than by parts'[2] is the more efficient method. Whenever such experimental results have been presented the investigator has attempted an explanation of why learning by smaller units should be found more efficient as a learning means.

Continued investigation with respect to this matter seems to give stronger and stronger evidence that for maze learning (motor learning)[3] the smaller unit methods are not a little, but are very much, better as learning means than is the case for very large ones.[4] Similar results are being found for other forms of learning.

The data for this study were obtained during the second semester of the school year 1920–21. The subjects used were members of one of the psychology classes made up of six males and twenty-eight females. These subjects were assigned to the various method-groups by chance selection. The 'whole method' group was made up of 2 males and 10 females, the 'part continuous method' group of 2 males and

[1] Peckstein, L. A., 'Whole Versus Part Method in Learning Nonsensical Syllables,' *Jr. Ed. Psychology*, 1918, p. 387.

[2] Starch, Daniel, *Educational Psychology*, 1921, p. 185.

[3] Possibly all learning is motor and that the different types indicated by most writers are only evidences of the specific nature of the nerves involved in the respective aspects of adjustment.

[4] I appreciate the uncertainty of meaning attached to the words 'whole' and 'part' in discussions on learning. I suppose no one doubts that a unit of practice might be made too large for adequate learning for any individual in any field of study. No one can mean such a 'whole' as this in such discussion, but just what is meant has been defined for each particular case as it has come up.